FIELD INVESTIGATION OF GEOSYNTHETICS USED FOR SUBGRADE STABILIZATION

<u>Research Proposal</u>

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1 Problem Statement

The use of stiff geosynthetics in unpaved roads on soft subgrade is known to provide a reinforcing benefit to the road allowing better distribution of applied loads and increased bearing capacity, especially for fill depths of less than 0.4 m and subgrades with a CBR of less than 3. Overall the reinforcing benefit of a geosynthetic can be directly seen in rut formation, with up to ten times as many standard axle passes needed than for an unreinforced road. Other non-independent benefits have also been documented: improved bearing capacity, extended service life, reduced fill thickness, and diminished deformations (Hufenus et al., 2006).

Design of a geosynthetic unpaved road should take into consideration the results of preceding laboratory and field investigations because there is not yet an accepted standard design technique that incorporates the material properties of the geosynthetic in the design to account for the reinforcement due to their inclusion. Placement of the geosynthetic depends on the fill depth, in which it should be placed directly on the subgrade for fills less than 0.4 m and approximately 0.25 to 0.35 m below the surface for greater fill depths. In any case, the geosynthetic should be topped by a minimum of 0.2 m of fill to prevent direct damage from traffic loads. For very soft subgrades, with decreasing CBR (especially less than 3), a greater stiffness of the geosynthetic (based on its tensile stiffness measured at 2% tensile strains), can provide benefits somewhat proportional to the reinforcing benefit (Hufenus et al., 2006).

The limitation of realistic traffic loading reproduction in the laboratory lends much credence to field investigations of geosynthetic performance as well as installation survivability. A recent field test in Diessenhofen, Switzerland examined the effects of geosynthetics on unpaved roads, but the variability in CBR of the natural subgrade was undesirable and scarification and regrading attempts were unsuccessful (Hufenus et al., 2006).

The performance of geosynthetic material, particularly junction integrity, under traffic loading in field conditions is also desirable. While laboratory tests can indicate junction strength by a number of methods (Christopher et al., 2007), the survivability of the junction to installation and loading requires field investigations.

2 Project Objectives and Benefits

This project aims to construct test sections in the field to investigate the relative benefit of various geosynthetics available on the market to an unpaved road. A prepared and placed subgrade will provide equivalent conditions for each test section; likewise the gravel surfacing along the entire test bed will be uniform. Controlled traffic loading with frequent rut profile measurements will indicate performance benefits of each geosynthetic in the test sections. Additionally, post-traffic examination of the geosynthetic will provide invaluable information regarding the performance and installation survivability of the geosynthetics.

3 Project Methodology

The work plan for this project consists of the following tasks, which are described more fully below. These tasks have been designed to address the stated research objectives.

Task 0 – Project Management

NAUE GmbH & Co. KG, a geosynthetic manufacturer based in Germany with distribution offices worldwide, is funding the baseline cost of this effort through an individual contract with the Western Transportation Institute. The contract between WTI and NAUE will provide funding to construct and monitor four test sections and also will cover the majority of the person hours associated with the instrumentation, analysis and reporting tasks associated with the overall project. The added construction, monitoring and analytical work associated with the additional test sections requested by MDT will be part of a second contract with WTI. Together these efforts comprise a single project which will be managed by WTI. As such, WTI will maintain a seamless connection between each of these separate contracts through frequent and open communication between all parties as they simultaneously administer both contracts. Data collected and conclusions drawn from each of these parallel projects will be summarized in a single final report that will be delivered to both constituents at the end of the project. Any information, data or conclusions generated during the course of the project will be shared with both NAUE and MDT as the project progresses. Any modifications to the scope or budget must be approved by all parties before being executed.

Task 1 – Design and Construction of Test Sections

The proposed location of the geosynthetic test sections is in Lewistown, Montana at a research facility operated by the Western Transportation Institute. The facility includes 230 acres, of which 64 acres of abandoned runways and taxiways provide an excellent foundation to support a variety of research projects. The test sections will be constructed directly adjacent to or within an existing taxiway which will provide a convenient return lane without additional construction. Poor subgrade material consistent with AASHTO soil classifications A-6 and A-7 have been identified nearby and will be transported to the facility to provide the subgrade for the test bed. This subgrade material will be prepared and compacted to have low strength (CBR less than 2).

Design of the experiment is based on eleven test sections that are 4 m wide. Two control sections (i.e., no geosynthetic) will also be constructed on both ends of the test plot as shown in Figure 1. Each test section containing geosynthetics will be 15 m long and the control sections will be 20 m long. Construction activities basically include the excavation and placement of the subgrade, geosynthetic, and gravel surface. Excavation of 1.2 m of native soil will allow approximately one meter of the soft subgrade to be installed. The properties of the prepared subgrade, measured using the field vane shear test, will be as uniform as possible throughout the excavated test bed. Geosynthetics will be installed above the subgrade in all but two test sections, which will be used as controls. A gravel surface of approximately 0.3 m depth will be engineered based on the actual subgrade properties and vehicle load. Deconstruction of the test sections is not anticipated so that additional observations can possibly be made or so that future studies may be conducted.

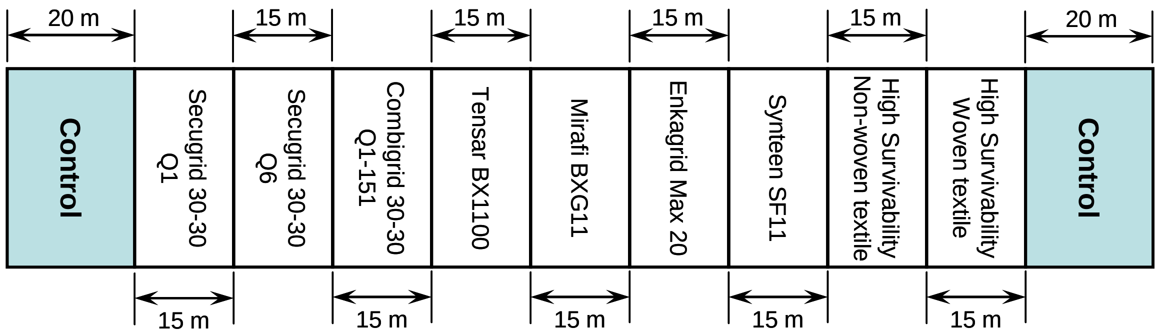

Figure 1. Layout of test sections.

Task 2 – Soil Testing and Instrumentation

The prepared subgrade properties that will be measured include water content, Atterberg limits, and perhaps particle size distribution to determine soil classification. Laboratory CBR tests will be done before construction and field measurements of vane shear, in substantial accordance to ASTM D2573, will be conducted to ensure subgrade uniformity.

The proposed methodology and budget includes displacement measurements on the geosynthetic at two locations in each of the geosynthetic-stabilized test sections and a single measurement of pore pressure within the subgrade of all sections. In the event that the distribution of the pore pressure transducers deviates from this plan, approval will be sought from all parties prior to installation. Displacement measurements will be used to determine strain in the geosynthetic and to calculate the relative elongation due to rut formation. Estimation and back calculation of strain and displacement will also be deduced and verified based on rut measurements made during loading and forensic evaluations after loading. The use of detailed rut measurements to calculate strain in the geosynthetic was demonstrated and showed good agreement to strain gage data in the full-scale field trials in Diessenhofen, Switzerland (Hufenus et al., 2006).

Task 3 – Vehicle Loading and Data Collection

Completion of construction will be followed by controlled vehicle loading using a three-axle dump truck. The vehicle will travel over the test bed in one direction for up to 1000 passes or until ten centimeters of rutting occurs in all test sections. To avoid excessive rutting in any section, a level surface will be restored with gravel once a section has 10-cm ruts. Periodic measurement of the profile of the test sections will be taken at three predetermined locations of each test section to record the number of passes to achieve an average rut depth of 2.5, 5, 7.5, and 10 cm. Data will also be continuously collected from embedded instrumentation during the loading sequence.

Once loading is complete, a strip of gravel 0.3 to 0.6 m wide perpendicular to the direction of loading will be removed to allow detailed measurement of the rut bowl at the level of the subgrade and thorough inspection of the geosynthetic materials. Additionally, along one rut in each test section, a strip of gravel approximately 1 m wide and 3 m long will be removed to evaluate installation damage and junction survivability (in substantial accordance with ASTM D5818). Geosynthetic test samples will be undergo tension testing before and after loading. The vane shear of the subgrade in each of the excavated areas will also be measured after the loading sequence.

Task 4 – Analysis

The research analysis will be based on a cumulative examination of all data, including subgrade, geosynthetic, and gravel properties; road performance; and physical post-testing examination of the geosynthetic and subgrade. The analysis will be the basis for a comprehensive explanation of the results indicating the performance of each geosynthetic relative to other geosynthetics and the control section.

Task 5 – Reporting

A final report will be prepared to summarize detailed construction information and performance results for each test section. Progress reports will also be delivered throughout the project on a quarterly basis or according to another mutually agreed upon schedule.

4 Project Staffing and Administration

Eli Cuelho and Steven Perkins will be Co-Principal Investigators for this research project. It is assumed that Barry Christopher (Christopher Consultants) will provide technical advice throughout this project. Mr. Cuelho will be the primary manager and the point of contact with the Montana Department of Transportation. Both Principal Investigators will be responsible for ensuring that the objectives of the study are accomplished, implementing the project tasks, and preparing the final report.

Mr. Eli Cuelho – Co-Principal Investigator

Mr. Eli Cuelho is a Research Engineer at the Western Transportation Institute at Montana State University. Mr. Cuelho is a licensed professional engineer in the state of Montana and is currently involved with a number of research projects related to the design and maintenance of transportation infrastructure. He has experience with ITS technology evaluation and deployment, cost-effectiveness and cost-benefit analyses, remote sensing and data acquisition equipment, geotechnical engineering, geosynthetic design, and pavement design and analysis. Mr. Cuelho has been involved with geosynthetic research for the past 12 years, and has conducted the following relevant studies: *Development of Test Protocols for the Characterization of Soil/Geosynthetic Interaction and Intrinsic Geosynthetic Material Properties, Geosynthetic Pullout under Small Displacements, Determination of Geosynthetic Constitutive Parameters and Soil/Geosynthetic Interaction by In-Air and In-Soil Experiments.*

Dr. Steven Perkins – Co-Principal Investigator

Dr. Perkins has over twelve years of experience working on projects related to geosynthetics and in particular projects related to geosynthetic reinforcement of pavements. Dr. Perkins has been the PI of ten research projects focused on aspects of reinforced pavements ranging from the measurement of field performance of reinforced pavements to the development of design methods. In these projects, work components have included the development of material testing methods and the use of instrumentation for the measurement of material response. Dr. Perkins has written over 40 articles, reports and book chapters and has given over 50 presentations related to geosynthetics. Dr. Perkins has been involved in the preparation of several synthesis reports for NCHRP and AASHTO on research and practice of geosynthetics in pavements. Dr. Perkins has assisted with the development and delivery of several short courses and workshops on Pavement Design with Geosynthetics sponsored by industry and agency groups and delivered to practicing engineers and DOT's.

Research Assistants

Mr. Cuelho and Dr. Perkins will be supported by Doug Cross, Michelle Akin and Montana State University students. Doug Cross will primarily be responsible for construction and coordination of the test sections. Mr. Cross has over ten years experience with construction materials and applied research and will provide valuable insight in working with poor subgrade material. Ms. Akin will assist in the analysis and reporting, relying on a background of civil engineering and extensive project experience.

5 Schedule

The estimated project schedule is depicted in Table 1. The total proposed duration of the project is 12 months, with an estimated start date of March 3, 2008, and an estimated completion date of February 27, 2009.

Table 1. Project Schedule

Work Tasks	Milestone Dates	2008										2009	
		Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb
Project Commencement	Mar. 3, 2008	★											
Kickoff Meeting	Mar. 20, 2008	★											
1 – Design and Construction													
2 – Soil Testing and Instrumentation													
3 – Vehicle Loading & Data Collection													
4 – Analysis													
5a – Submit Draft Report	Dec. 31, 2008										★		
5b – Review & Address Comments													
5c – Submit Final Report	Feb. 27, 2009												★

6 Budget

The total funding needed for this proposed research project consisting of eleven test sections (9 geosynthetics and 2 controls) is $235,203. NAUE GmbH & Co. KG will fund the baseline component of this research project which consists of three geosynthetic-stabilized test sections and a control for $82,957. The cost of the remaining seven test sections ($86,746) will be paid for by MDT. The Western Transportation Institute will help offset some of the costs by providing $65,500 toward this effort which will be distributed between the two separate contracts. A detailed breakdown of the costs for MDT and WTI is shown in Table 2. Construction contracts will be administered for construction, live-load testing, and excavations associated with post-loading evaluation of the test sections. Expendable supplies include geosynthetics, instrumentation, profilers, marking supplies, and other miscellaneous items necessary to accomplish the goals of this project. An itemized budget based on state and federal fiscal years for MDT's contribution is shown in Table 3.

In-state travel will cover trips taken to the test site in Lewistown, Montana to monitor construction of the field test sections, observe the progression of damage during traffic loading and to collect data during testing. The estimated total number of person-hours needed to complete the work described in this proposal is 1949 as detailed in Table 4.

Table 2. Detailed Budget for MDT and WTI

Item	MDT	WTI	Total
Salaries	$8,641	$7,940	$16,581
Benefits	$3,111	$1,376	$4,487
In-State Travel	$3,500	$875	$4,375
Expendable Supplies	$11,473	$2,868	$14,341
Construction Contracts	$54,677	$13,669	$68,346
Tuition	$0	$2,000	$2,000
Direct Costs	$81,401	$28,729	$110,130
Overhead	$5,345	$5,420	$10,765
Total Project Cost	**$86,746**	**$34,149**	**$120,895**

Table 3. Itemized Budget for MDT Based on State and Federal Fiscal Years

Item	State Fiscal Year		Federal Fiscal Year	
	FY 2008	FY 2009	FY 2008	FY 2009
Salaries	$3,889	$4,753	$6,049	$2,592
Benefits	$1,400	$1,711	$2,177	$933
In-State Travel	$1,575	$1,925	$3,325	$175
Expendable Supplies	$6,310	$5,163	$11,473	$0
Construction Contracts	$41,007	$13,669	$54,677	$0
Tuition	$0	$0	$0	$0
Direct Costs	$54,181	$27,220	$77,701	$3,701
Overhead	$2,635	$2,710	$4,605	$740
Totals	**$56,816**	**$29,930**	**$82,306**	**$4,440**

Table 4. Summary of Total Person Hours

Work Tasks	Principal Investigators	Research Assistants	Admin. Staff	Totals
0 – Project Management	89	0	16	**105**
1 – Design and Construction	53	177	8	**238**
2 – Soil Testing and Instrumentation	66	229	0	**295**
3 – Vehicle Loading & Data Collection	38	536	8	**582**
4 – Analysis	75	261	0	**336**
5 – Reporting	104	289	0	**393**
Totals	**425**	**1492**	**32**	**1949**

7 References

Christopher, B.R., E.V. Cuelho, and S.W. Perkins (2007) “Development of Geogrid Junction Strength Requirements for Reinforced Roadway Base Design” paper submitted to the First Pan American Geosynthetics Conference & Exhibition, March 2-5, 2008, Cancun, Mexico.

Hufenus, R., R. Rueegger, R. Banjac, P. Mayor, S.M. Springman, R. Brönnimann (2006) “Full-scale field tests on geosynthetic reinforced unpaved roads on soft subgrade” *Geotextiles and Geomembranes* 24(1), p.21-37.